Special Issue of “Optimal Selenium Status and Selenoproteins in Health”

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Selenium, an essential trace element, supports various cellular and physiological functions and prevents certain chronic and infectious diseases mainly through selenoproteins. At nutritional levels of intake, body selenium is mainly orchestrated for selenoprotein expression. Keshan disease is the first identified selenium-deficient syndrome characterized by congestive cardiomyopathy in the presence of a mutated strain of coxsackievirus B3 accompanied by severe selenium or glutathione peroxidase 1 deficiency [1]. It is becoming clear that selenium or selenoprotein deficiency implicates the pathogenesis of cancer, type 2 diabetes, neuronal degenerative diseases, and cardiovascular diseases in association with imbalance between generation and elimination of reactive oxygen or nitrogen species [2, 3]. Above nutritional needs (55 µg/day for adults), selenium may be beneficial at a very narrow window to prevent certain types of cancer [4]. As the doses increase, selenium toxicity may also exacerbate the disease, and therefore, its tolerable upper intake level is set at 400 µg/day in humans [5]. However, further research is needed to understand how this impacts selenoprotein pools in specific tissues/cells and non-specific incorporation of selenium and the mechanistic underpinnings in appropriate animal and cell models.

There is a total of 25 selenoproteins in humans, and the numbers vary by species [2]. Human selenoproteins are categorized into glutathione peroxidases (GPX1–4; 6), thioredoxin reductases (TXNRD1–3), iodothyronine deiodinases (DIO1–3), the thioredoxin-like Rdx family (SELENOW, SELENOT,

SELENOH, and SELENOV), and others (SELENOF, SELENOM, SELENOI, SELENOK, SELENOS, SELENOO, SELENON, SELENOP, methionine-*R*-sulfoxide reductase 1, and selenophosphate synthetase 2). While the list of human selenoproteins was confirmed in 2003 [6], many of them remain poorly studied and their functions less well understood. Another line of study that warrants further investigation is the biological role of non-selenoprotein and selenium metabolites that are regulated by selenium deficiency and/or supranutritional levels of selenium [7].

This special issue encompasses two original research and six review articles. The two research articles investigate selenium interactions with other minerals. Guo et al. demonstrate a link between selenium- and magnesium-related genes through a cDNA microarray analysis of peripheral blood mononuclear cells from Keshan disease patients [8]. Furthermore, an international team from Russia, India, and China report the analysis of wheat samples grown in a selenium-enriched area of Punjab in India and show increases in a few other minerals in selenium-enriched wheat and bread [9]. While in vitro studies using such cereal extracts have led to alleviation of inflammatory gene expression in immune cells [10], the effect of consumption of selenium-enriched cereals on human and animal health remains to be further examined.

Co-translational incorporation of selenocysteine is guided by in-frame UGA codons and the selenocysteine insertion sequence (SECIS) at the 3'-untranslated region of selenoprotein mRNAs, together with *trans*-acting factors [2]. Michael Howard and Paul Copeland discuss current understanding of UGA codon redefinition for selenoprotein expression and highlight two novel areas of selenocysteine incorporation research [11]. Lucia Seale, Marla Berry, and colleagues present an excellent review with a focus on selenoprotein degradation and selenocysteine recycling [12]. From a systems biology perspective, Yan Zhang and his colleague review selenium status and selenoproteins in human diseases [13]. The essentiality of selenium and selenoproteins in optimal health is specifically exemplified by in-depth reviews of SELENOP, GPX1, SELENOF, and selenium-binding protein 1 in prostate cancer

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by Alan Diamond [14], SELENOK in immunity and cancer by Peter Hoffmann and his colleague [15], and the role of several selenoproteins in bacterial pathogenesis by Kirimanjeswara et al. [16].

These eight articles in this special issue of *Biological Trace Elements and Research* serve as timely demonstration of where the current selenium research in optimal health stands through its impact on food production, disease prevention, and understanding the basic mechanisms, with insights and directions for future studies.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Beck MA, Esworthy RS, Ho YS, Chu FF (1998) Glutathione peroxidase protects mice from viral-induced myocarditis. *FASEB J* 12: 1143–1149
2. Labunskyy VM, Hatfield DL, Gladyshev VN (2014) Selenoproteins: molecular pathways and physiological roles. *Physiol Rev* 94:739–777
3. Lei XG, Zhu JH, Cheng WH, Bao Y, Ho YS, Reddi AR, Holmgren A, Arnér ES (2015) Paradoxical roles of antioxidant enzymes: basic mechanisms and health implications. *Physiol Rev* 96:307–364
4. Combs GF Jr (2004) Current evidence and research needs to support a health claim for selenium and cancer prevention. *J Nutr* 135: 343–347
5. Yang GQ, Wang SZ, Zhou RH, Sun SZ (1983) Endemic selenium intoxication of humans in China. *Am J Clin Nutr* 37:872–881
6. Kryukov GV, Castellano S, Novoselov SV, Lobanov AV, Zehtab O, Guigo R, Gladyshev VN (2003) Characterization of mammalian selenoproteomes. *Science* 300:1439–1443
7. Zhang L, Zeng H, Cheng WH (2018) Beneficial and paradoxical roles of selenium at nutritional levels of intake in healthspan and longevity. *Free Radic Biol Med* 127:3–13
8. Wang S, Yan R, Wang B, Meng P, Tan W, Guo X (2019) The functional analysis of selenium-related genes and magnesium-related genes in the gene expression profile microarray in the peripheral blood mononuclear cells of Keshan disease. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01750-2>
9. Skalnaya MG, Tinkov AA, Prakash NT, Ajsuvakova OP, Jaiswal SK, Prakash R, Grabeklis AR, Kirichuk AA, Zhuchenko NA, Regula J, Zhang F, Guo X, Skalny AV (2019) Selenium and other elements in wheat (*Triticum aestivum*) and wheat bread from a seleniferous area. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01776-6>
10. Dhanjal NI, Sharma S, Skalny AV, Skalnaya MG, Ajsuvakova OP, Tinkov AA, Zhang F, Guo X, Prabhu KS, Tejo Prakash N (2019) Selenium-rich maize modulates the expression of prostaglandin genes in lipopolysaccharide-stimulated RAW264.7 macrophages. *Food Funct* 10:2839–2846
11. Howard MT, Copeland PR (2019) New directions for understanding the codon redefinition required for selenocysteine incorporation. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01827-y>
12. Ha HY, Alfulaij N, Berry MJ, Seale LA (2019) From selenium absorption to selenoprotein degradation. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01771-x>
13. Ying H, Zhang Y (2019) Systems biology of selenium and complex disease. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01781-9>
14. Diamond AM (2019) Selenoproteins of the human prostate: unusual properties and role in cancer etiology. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01809-0>
15. Marciel MP, Hoffmann PR (2019) Molecular mechanisms by which Selenoprotein K regulates immunity and Cancer. *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01774-8>
16. Sumner SE, Markley RL, kirimanjeswara GS (2019) *Biol Trace Elem Biol*. <https://doi.org/10.1007/s12011-019-01877-2>

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